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Research Report

THE RELATIONSHIP OF AROUSAL MEASURES TO SUBSEQUENT BEHAVIOR

I. GROUP ESTIMATES OF INDIVIDUAL STRESS SUSCEPTIBILITY

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Bureau of Medicine and Surgery
Project MR005.13-3003
Subtask 14 (Report No. 1)

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Project MR005.13-3003 Subtask 14, Report No. 1. Pensacola, Fla.: Naval School of Aviation Medicine, 18 April.

The relationship between physiological arousal measures taken under three physically threatening conditions and ratings of stress susceptibility was investigated. Consistency in arousal response was also examined. The arousal measures are designated as changes in pulse and blink rate under threat of physical pain. Stress susceptibility is defined as over-reactivity to threat of impending physical pain as estimated by peer ratings. The results indicated a significant relationship between one blink rate measure and ratings of stress susceptibility, and a partial interstress and intermeasure consistency of response to physical threat. The use of muscular tension measures (e.g., blink rate) for predictive purposes appears to have potential value.

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Aviation personnel - Selection

Stress - Psychological factors
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SUMMARY PAGE

THE PROBLEM

It has been demonstrated that anxiety reactions of naval cadets in a decompression chamber are significantly related to later anxiety toward flying. This supports the use of behavior in "miniature" stress situations for prediction and selection purposes. This report is a further investigation of the "miniaturized" stress rationale. The relationship between two physiological arousal measures and ratings of stress susceptibility was examined. Consistency in arousal response to threat was also investigated. The feasibility of using arousal measures for predictive purposes was considered.

FINDINGS

This report demonstrates that arousal change-scores obtained under naval pre-flight stresses can be incorporated into the miniaturized stress rationale. The results indicate a significant relationship between one blink rate measure and ratings of stress susceptibility, and a partial interstress and intermeasure consistency of response to physical threat. It was tentatively concluded that the use of muscular tension measures (e.g., blink rate) for predictive purposes appears to have potential value.

INTRODUCTION

Research in the area of predicting individual behavior under military stresses has produced conflicting results. Studies which did not produce significant findings are those by the Office of Strategic Services (19) and by Melton (16). The findings, however, seem quite possibly a function of inadequate criteria rather than a demonstration of a lack of relationship between behavior under experimentally induced stress and subsequent performance.

More recently, Voas, Bair, and Ambler (24) reported that anxiety reactions of naval cadets in a decompression chamber were significantly related to later anxiety toward flying. The use of "miniature" stress situations as predictors and criteria was discussed. Their study represented an advance over previous flight selection studies because of realistic stressors and refined criteria. The value such measures would have for selection purposes, albeit only as secondary screening devices, is evident. Therefore, they suggested that further investigation in this area employing more objective measures of psychological stress might demonstrate the validity and feasibility of using behavior in "miniaturized" stress situations as predictive measures of later performance under stress (e.g., success or failure in naval flight training).

The present study is a further investigation of the miniaturized stress rationale. It provides a preliminary check on certain relationships between physiological arousal measures and ratings of an individual's stress susceptibility. The results in this area would assist in appraising our initial objective, i.e., relating physiological indicants of stress to subsequent separation from the program.

This investigation necessarily cuts across several important areas of research. Since actual training situations were used to produce realistic stresses, it was expedient to use the simple measurement of pulse and eyeblink as the indices of arousal and tension under stress. Among other measures, pulse stress scores have been used as a measure of arousal in many recent studies (3,8,25). Blink rate has been proposed by Meyer (17) as a measure of generalized muscular tension. Doehring (6) reported a significant relationship between blink rate response to verbal stress and levels of anxiety and muscular tension. Meyer *et al.*, (18), concluded that, in general, blink rate may be used as an index of generalized muscular tension.

This study also involves the general areas of the nature and measurement of stress. The subtle semantic and philosophical problems involving the nature of stress and the critical questions concerning what measurement techniques to use persist as basic issues in this area of research. Martin (15) points out that one's theoretical approach to anxiety affects how one goes about measuring it. We agree that this is true not only for one emotional construct, but also for testing a generic concept such as psychological stress. In the present report stress is not to be confused with physical stress itself but is associated with the anticipation of a physically threatening situation. This is closely related to other conceptions of psychological stress which equate it to

the resultants (4) or to "psychological homeostatic" upset due to stress (12,14,21). Operationally, it is defined here as that degree of arousal to physical threat reflected by pulse and blink rate. It has been indicated that such a definition should be incorporated in any approach to this problem on the empirical level (2).

The interpretation of physiological measurements under stress is also problematic. The question of what type of transformation, if any, to use on change scores is a general problem (7,14,15). A check on the literature reveals a bewildering array of transformations which have made intercomparisons and replication of results difficult. Wilder's (26) contribution of the "Law of Initial Values" has particularly influenced thinking on autonomic difference scores. Briefly, it states that the magnitude of change which occurs under stress will be a function of the pre-stress level of the indicant. On the basis of that work, Lacey (13) has proposed a general solution to the problem by taking into account the homeostatic restraint of response. This autonomic restraint provides an objective explanation for the usual negative relationship observed between initial level and magnitude of change due to stress. His autonomic lability score corrects for this negative relationship. As such, it appears to be one of the more realistic and meaningful transformations of autonomic difference scores.

High correlations, however, have been observed between lability scores and absolute and percentage changes (13). Furthermore, a convincing, but not conclusive, doubt has been cast on certain aspects of the "Law of Initial Values" (11). Therefore, it cannot be asserted at this time that the use of any one procedure for analyzing physiological data is likely to be the best (4). Consequently, in the treatment of the data in this report two methods were employed.

PROCEDURE

SUBJECTS

The subjects employed in this experiment were 190 pre-flight students in the Naval Air Training Program. The subjects were informed that all ratings were confidential material and obtained for research purposes only.

MEASURES

Three pulse measures and two eyeblink measures were obtained from each subject under three different physically threatening conditions. A peer rating estimate on stress susceptibility was also obtained during the seventh week of pre-flight orientation.

SITUATIONS

The three situations which were judged to be physically threatening were: the needle puncture for blood sample during physical examination, the ride on the "Dilbert Dunker" (a training device for underwater aircraft escape), and the simulated high altitude ascent in the low pressure chamber. Other situations in the flight training

syllabus could have generated as much or more physical threat but were not well adapted to the experimental procedures outlined in this report. On the other hand, the three situations mentioned enabled pulse and blink rate measurements to be obtained quickly, efficiently, and without any interference in the pre-flight training procedures. (Blink rate, however, could not be measured in the low pressure chamber.)

STIMULUS

The actual stress stimulus was not defined as the pain or experience of the physically threatening situations themselves but as the anticipation of these conditions. By design this approximates, on a short term basis, the anticipation syndrome associated with the prolonged potentially threatening conditions in the flight training program.

STRESS RATINGS

The peer rating format called for each man to rate those whom he thought were the three most stress susceptible individuals and the three least stress susceptible individuals in his class. This rating was administered during the seventh week of pre-flight school. The peer rating technique was considered superior to other paper-pencil methods of assessing personality characteristics. Peer ratings have been shown to be valid (22) and highly reliable (10). The effectiveness of peer ratings apparently comes from the fact that they are based upon many observations of behavior during close association over long periods of time.

The format contained an operational definition of psychological stress which the subjects used as a frame of reference in judging their peers for stress proneness. It was stated thus:

"The anticipation of some impending threat or pain can cause one to be: nervous, uneasy, sweaty, short-breathed, pale, etc. Every person exhibits these reactions occasionally; some more often than others."

In order to avoid confusion in the minds of the subjects as to what was meant by the term psychological stress, the more popular term "anxiety" was employed on the forms. The arousal symptomatology included in the definition is typical of that observed while the subjects anticipated the three threatening conditions of this study. These reactions have been associated with "anxiety" due to flying (1).

METHOD

Standardized procedures were employed in obtaining the physiological arousal measures of pulse and blink rates. In order to quantify these reactions to threat, both pre-stress and stress level measures were necessary for each variable in each situation. These yielded a difference score which was the basis for the physiological stress scores used.

The nonstress measures are relative in the sense that the nonstress condition itself is a period within a long term continuum of stress beginning with the subject's arrival for pre-flight indoctrination. With this fact in mind, all resting level measures were taken in an atmosphere of as quiet inactivity as possible. A ten-minute rest period in the seated position preceded these measurements. The resting pulse measures represented an average of two measurements, of one minute duration, taken three minutes apart. In order to facilitate pulse measurement for a large number of subjects, the resting level pulse rate was obtained by the subjects themselves. This was done after ample demonstration and practice trials. The method of self-determination of pulse rate was shown by Voas (23) and Salit (20) to have a reliability coefficient of .93. We found a test-retest reliability of .95.

The nonstress blink rate was likewise determined under quiet conditions. Unknown to the subjects, an assistant was observing their blink rate per minute. In order to avoid suspicion, no specific instructions were given except to say speaking was not permitted. Bunnell (5) reported a retest reliability of .93 for blink rate. A .95 reliability under nonstress conditions was found in the present study.

The stress measures are also relative for the same reason mentioned above. The experimental data therefore consist of measurements of arousal under short-term stress conditions which can be considered part of a long-term continuum of stress (i.e., pre-flight training program). Apparently not much has been done from this point of view (9).

Prior to obtaining the stress scores in each threatening situation, the subjects were seated for approximately three minutes. After this pause, each individual was subjected to one of the stress conditions. (The same procedure was used in all three stress situations.) The measurement of pulse and blink rate did not take place during the stress itself but just prior to the pain or experience of the stress. This was defined as the "period of anticipation." The experimenter took the pulse rates of each individual as his respective turn approached for the blood sample and "Dilbert Dunker." (Due to exigencies of the pressure chamber, the self-determination method of pulse rates was employed.) At the same time, an assistant observed each subject for blink rate. Again, in order to avoid suspicion of eyeblink observation, the only instructions given were for the subjects to remain silent. Spot interviews eliminated any doubts on this point.

RESULTS AND DISCUSSION

The results partially confirm the rationale of this investigation and indicate some relationships of possible practical significance. The rationale underlying this investigation was that, if arousal measures taken under stress have any relationship with ultimate failure in the flight program for reasons of psychological stress, they might also be related to an intermediate estimate of stress susceptibility. Here, the arousal measures are designated as pulse and blink rate, and stress susceptibility is defined as over-reactivity to threat of impending physical pain as estimated by peer ratings.

Secondly, based on the stress prone individual concept, it was also suggested that there should be some degree of interstress consistency in response to the anticipation of an impending physical pain. The relationships within these two areas were examined in order to determine the feasibility of investigating the ultimate relationship of these indices of arousal under physical threat to subsequent failure in or withdrawal from the flight program for reasons of expressed psychological stress toward flying. Some meaningful relationships in the assumptions given above were the prerequisites established for further research along this particular line.

The results indicate a significant (at .01) tendency for blink rate under the needle stress to be related with ratings of stress susceptibility. Significant correlations of .28 and .25 between these two variables were obtained using absolute change and lability transformed scores, respectively (Table I). Although pulse rate did not exhibit a significant relationship with ratings of stress susceptibility, correlations in this area were in the expected direction. In this regard, a correlation of .15, using transformed pressure chamber pulse scores, was low but suggestive of some relationship. These results, therefore, tentatively suggest that there is some relationship between the arousal measures used and ratings of stress proneness, particularly with the blink rate index. We are inclined to think that perhaps blink rate was one of the overt criteria by which individuals rated their peers as stress susceptible.

Table I

Relationship between Measures of Arousal and Ratings of Stress Susceptibility

	N	Absolute Change	Lability Score
Pulse (Needle)	184	.06	.06
Pulse (Dilbert Dunker)	105	-.07	.05
Pulse (Pressure Chamber)	136	.00	.15
Blink (Needle)	185	.28*	.25*
Blink (Dilbert Dunker)	101	.10	-.01

* Significant at .01.

It was found that only pulse rate exhibited some consistency of response in two different stress situations (Table II). Furthermore, a significant relationship was obtained between pulse rate and blink rate under the same stress condition (i.e., needle situation). Therefore, the data tentatively illustrate some interstress and inter-measure consistency in response to physical threat.

Table II

Intercorrelation of Pulse and Blink Measures

	1	2	3	4	5
1. Pulse (Needle)	# ##	.10 .36*	.04 .06	.24* .18*	-.09 -.06
2. Pulse (Dunker)		-- --	.00 -.01	-.09 -.04	-.01 .08
3. Pulse (Chamber)			-- --	.23* .18*	-.03 .08
4. Blink (Needle)				-- --	.04 .02
5. Blink (Dunker)					-- --

Lability Scores; ## Absolute Change Scores; * Significant at .01.

On the other hand, no significant relationships were found between the "Dilbert Dunker" blink measure and other variables (Table II). Neither was any relationship demonstrated between this particular measure and the stress-prone ratings (Table I). This contrasts with the significant correlations obtained with the needle stress blink measures. Since a significant relationship was found between stress-prone ratings and needle blink rate measures, it would seem prudent to examine more closely these two variables. Yet, pending further investigation with more refined criteria (i.e., success-failure), the positive findings along this line are suggestive but not conclusive.

Based on the significant relationship found between blink rate under needle stress and the stress-prone ratings, further investigation into the practical significance of blink rate was made (Tables III and IV). If the relationship has significance of any value, it should discriminate between the upper and lower extremes of each variable. The underlying question is, "Do high and low blink changes also tend to indicate high and low stress-prone ratings, respectively?" By use of sigma and quartile extremes for the levels of comparison, differences between the high and low group means of blink rate and stress-prone ratings were tested for significance. In order to check the consistency of this relationship, the regressions of the variables were made on each other (e.g., x on y , and y on x). The results indicate that a true difference exists between the high and low groups of both blink change and stress-prone ratings for each level of

comparison. The data illustrate that the scores of these two variables reciprocally tend to predict one another at the extremes. For all practical purposes, the use of lability scores and absolute change scores yielded identical results. Therefore, it is tentatively concluded that the use of muscular tension measures (e.g., blink rate) for predictive purposes appears to have potential value.

Table III

Inspection of the Relationship between Blink-Change and Stress-Ratings at the Extremes

1. Difference between Mean Blink-Change of High/Low Stress-Rated Groups

Stress-Rating Distribution	Blink-Change Scores				Diff.	p*
	N ₁ (High)	N ₂ (Low)	M ₁	M ₂		
Top and bottom 25%	46	46	11.24	8.30	2.94	.05
Greater than ± 1 S.D.	28	20	12.53	7.90	4.63	.02

2. Difference between Mean Stress-Ratings of High/Low Blink-Change Groups

Blink-Change Distribution	Stress-Ratings of High/Low Blink-Change				Diff.	p*
	N ₁ (High)	N ₂ (Low)	M ₁	M ₂		
Top and bottom 25%	46	46	51.78	46.52	5.26	.01
Greater than ± 1 S.D.	39	32	52.92	46.66	6.26	.01

* t test of significance

Table IV

Inspection of the Relationship between Blink-Lability Scores
and Stress-Ratings at the Extremes

1. Difference between Mean Blink-Lability Scores of High/Low Stress-Rated Groups

Stress-Rating Distribution	Blink-Lability Scores					
	N ₁ (High)	N ₂ (Low)	M ₁	M ₂	Diff.	p*
Top and bottom 25%	46	46	51.65	49.24	2.41	n.s.
Greater than ± 1 S.D.	28	23	53.61	47.35	6.26	.02

2. Difference between Mean Stress-Ratings of High/Low Blink-Lability Groups

Blink-Lability Distribution	Stress-Ratings of High/Low Blink-Lability					
	N ₁ (High)	N ₂ (Low)	M ₁	M ₂	Diff.	p*
Top and bottom 25%	46	46	51.98	47.78	4.20	.01
Greater than ± 1 S.D.	32	35	52.09	47.14	4.95	.02

* t test of significance.

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